Patent claims

1. Device for ion beam acceleration, comprising:

(A) an ion accelerator tank (1) having a central container axis (2) for guiding and accelerating a pulsed ion beam (3) in the container axis (2),

(B) an electron beam pulse formation and amplification device (4) having an electron beam axis (5) for microstructuring and amplifying current pulses to supply the device for ion beam acceleration with high-frequency power,

characterised in that

the electron beam pulse formation and amplification device (4) is arranged with its electron beam axis (5) transverse and offset relative to the container axis (2) and comprises outside the ion accelerator tank (1)

(a) an electron gun (6),

(b) a high-frequency deflector (7),

(c) a d.c. voltage deflector (8),

(d) a collector (9) having an opposing field, and

(e) a post-deflection accelerator (10)

and comprises inside the ion accelerator tank (1)

(f) an output coupler (11) for coupling the power of the electron beam (14) to a consumer (12),

(g) a main collector (13) for taking up the residual power of the electron beam (14),

components (a) to (g) of the device being arranged behind one another in the direction of the electron beam (14).

2. Device according to claim 1, **characterised in that** the consumer (12) is the pulsed ion beam (3).

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3. Device according to either claim 1 or claim 2, **characterised in that** the output coupler (11) comprises a resonator (15) having in the ion accelerator tank (1) an upper annular gap (16) surrounding the electron beam (14) radially and a lower annular gap (17) surrounding the electron beam (14) radially.

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4. ~~Device according to any one of claims 1 to 3, **characterised in that** the output coupler (11) comprises a coupling stage (18) arranged between annular gaps (16, 17), which coupling stage surrounds the electron beam (14) coaxially and is arranged radially offset and transverse to the ion beam (3) inside the ion accelerator tank (1), the coupling stage (18) being fastened to a drift tube mounting (19) of the ion beam (14).~~

5. ~~Device according to any one of the preceding claims, **characterised in that** the electron beam gun (6) is a Pierce-type electron beam gun.~~

6. ~~Device according to any one of the preceding claims, **characterised in that** the high-frequency deflector (7) comprises a homogeneous transversely directed alternating field (20).~~

7. ~~Device according to any one of the preceding claims, **characterised in that** the d.c. voltage deflector (8) comprises a non-homogeneous temporally constant transverse electrical field (19).~~

8. ~~Device according to any one of the preceding claims, **characterised in that** the output coupler (11) comprises a resonator (15) in its output circuit.~~

9. Device according to claim 8, **characterised in that** the output circuit (21) comprises a single-column annular cavity (22) as resonator (15).

10. Device for electron beam pulse formation and amplification comprising
    (a) an electron gun (6),
    (b) a high-frequency deflector (7),
    (c) a d.c. voltage deflector (8),
    (d) a collector (9) having an opposing field,
    (e) an output coupler (11) for coupling the power of the electron beam (14) to a consumer (12), and
    (f) a main collector (13) for taking up the residual power of the electron beam (14), components (a) to (g) of the device being arranged behind one another in the direction of the electron beam (14).

11. Device according to claim 10, **characterised in that** the consumer (12) is an antenna (23) of a coaxial cable end (24), which projects into a resonator (15) that is coupled to the electron beam (14) by way of an annular gap (25) surrounding the electron beam (14).

12. Device according to claim 10, **characterised in that** the consumer (12) is an antenna coupler of a waveguide, the antenna coupler projecting into a resonator (15) that surrounds the electron beam (14) by means of an annular gap (25).

13. Device according to claim 10, **characterised in that** the consumer (12) is a coupling window to a waveguide, the coupling window opening to a resonator (15) that surrounds the electron beam (14) by means of an annular gap (25).

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14. Device according to any one of claims 10 to 13, **characterised in that** the electron beam gun (6) is a Pierce-type electron beam gun.

15. Device according to any one of claims 10 to 14, **characterised in that** the high-frequency deflector (7) comprises a homogeneous transversely directed alternating field (20).

16. Device according to any one of claims 10 to 15, **characterised in that** the d.c. voltage deflector (8) comprises a non-homogeneous temporally constant transverse electrical field (19).

17. Device according to any one of claims 10 to 16, **characterised in that** the output coupler (11) comprises a resonator (15) in its output circuit (21).

18. Device according to claim 17, **characterised in that** the output circuit (21) comprises a single-column annular cavity (26) as resonator (15).

19. Method for ion beam acceleration carried out using a device that comprises an ion accelerator tank ~~(1) having a~~ central container axis (2) for guiding and accelerating a pulsed ion beam ~~(14) in~~ the container axis (2) and an electron beam pulse formation and amplification device (4) having an electron beam axis

electron beam or (3)

(5) for microstructuring and amplifying current pulses to supply the device for ion beam acceleration with high-frequency power, wherein

the electron beam pulse formation and amplification device (4) is arranged with its electron beam axis (5) transverse and offset relative to the container axis (2) and produces an electron beam (14) by means of an electron gun (6) outside the ion accelerator tank (1), and

by means of a high-frequency deflector (7) and a d.c. voltage deflector (8) over 50% of the electron beam current is deflected, at frequencies of from 100 MHz to 400 MHz, at regular intervals into a collector (9) having an opposing field in order to microstructure the electron beam (14), and

a post-deflection accelerator (10), at an accelerator voltage of several 100 kilovolts, preferably from 200 to 400 kilovolts, guides the electron beam (14) into the ion accelerator tank (1), and

accelerates the ion beam (3) by way of an output coupler (11).

20. Method according to claim 19, **characterised in that** the electron beam (14) is subjected to intensity modulation that corresponds to the operating frequency (f) of the ion beam (3).

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21. Method according to claim 19 or claim 20, **characterised in that** ~~the collector (9) having an opposing field~~ takes up up to 80% of the electron beam energy.

22. Method for electron beam pulse formation and amplification that comprises the following method steps:
production of an electron beam (14) by means of an electron beam gun (5),
action upon the electron beam (14) of a high-frequency alternating field (20) with simultaneous high-frequency deflection of the electron beam (14),
high-frequency extraction of up to 80% of the electron beam energy to a collector (9) having an opposing field,

post-deflection acceleration of the high-frequency-modulated electron beam (14) to give electron beam pulses,
decoupling of the high-frequency energy by way of an output coupler (11).

23. Method according to claim 22, **characterised in that** the decoupling of the high-frequency energy is effected by way of a coaxial cable end (24) that projects, by way of an antenna (23), into an annular resonator chamber (27) that communicates with the high-frequency energy-rich electron beam (14) by way of an annular gap (25) surrounding the electron beam (14).

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24. Method according to claim 22 or claim 23, **characterised in that** the decoupling of the high-frequency energy is achieved by way of a waveguide which projects, by means of a coupling antenna, into an annular resonator chamber (27) that communicates with the high-frequency energy-rich electron beam (14) by way of an annular gap (25) surrounding the electron beam (14).

25. Method according to any one of claims 22 to 24, **characterised in that** the decoupling of the high-frequency energy is effected by way of a waveguide connected to an annular resonator (27) by way of a coupling window, the resonator (15) communicating with the electron beam (14) by way of an annular gap (25) surrounding the electron beam (14).

26. Method according to any one of claims 22 to 25, **characterised in that** an electron beam (14) having high perveance according to the Child-Langmuir equation is produced by an electron beam gun (6) with an electron beam of from 20 A to 60 A, preferably from 30 A to 50 A, at an acceleration voltage (U_c) of from 20 kV to 60 kV, preferably from 30 kV to 50 kV.

27. Method according to any one of claims 22 to 26, **characterised in that** the electron beam (14) is stabilised transversely in Brillouin equilibrium by means of a longitudinal magnetic field.

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28. Method according to any one of claims 22 to 27, **characterised in that** the intensity-modulated electron beam (14) excites a narrow-band HF resonator in the output circuit at an operating frequency (f).

29. Method according to any one of claims 22 to 28, **characterised in that** the electron beam (14) passes through a homogeneous transversely directed electrical alternating field (20).

30. Method according to any one of claims 22 to 25, **characterised in that** from 50% to 80% of the electron beam energy is deflected from the electron beam axis (5).

31. Method according to any one of the preceding claims 22 to 30, **characterised in that**, at virtually constant electron energy of from 30 keV to 50 keV, the deflected portion of the electron beam is collected in a biased collector (9) having an opposing field of from -30 kV to -40 kV.

32. Method according to any one of claims 22 to 31, **characterised in that** the energy of collected electrons is collected in a collector (9) having an opposing field and is fed as a charging current to the cathode of the electron beam gun (6).

33. Method according to any one of claims 22 to 32, **characterised in that** the undeflected electron packages move along the electron beam axis (14) at the temporal spacing of an operating frequency (f) and enter an output circuit (21) of the device, which output circuit is in the form of a resonator (15), at a main acceleration voltage of from 200 to 400 kV.

34. Method according to any one of claims 22 to 23, **characterised in that** a resonator (15) in the output circuit (21) of the device starts to operate, with high-frequency fields in the resonator (15) taking up the energy of the electrons, decelerating them and feeding an output circuit, preferably a coaxial cable end (24) and/or a waveguide.

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35. Method according to any one of claims 22 to 34, **characterised in that** residual energy of the electrons is deposited in a main collector (13).

36. Method according to any one of claims 22 to 35, **characterised in that** for electronic deflection in the high-frequency deflector (7) for an operating frequency (f) the actuated high-frequency signal consists of a main component at frequency (f/2) and superposition of frequency (5f/2) at an amplitude ratio of 5:1.

37. Device for high-frequency power amplification, especially for supplying a device having a cavity for ion beam acceleration with high-frequency power, comprising:
a vacuum tank having a central tank axis for producing and accelerating a pulsed electron beam (14) along the tank axis,
characterised in that
an electron beam pulse formation and amplification device (4) is arranged with its electron beam axis (5) transverse and offset relative to a container axis (2) of an ion accelerator tank (1) and comprises outside the ion accelerator tank (1)
(a) an electron gun (6),
(b) a high-frequency deflector (7),
(c) a d.c. voltage deflector (8),
(d) a collector (9) having an opposing field, and
(e) a post-deflection accelerator (10),
and comprises inside the ion accelerator tank
(f) a first gap and a second gap for coupling the power of the electron beam (14) to the ion beam (3),
(g) a main collector (13) for taking up the residual power of the electron beam (14),
components (a) to (g) of the device being arranged behind one another in the direction of the electron beam (14).

38. Device according to claim 37, **characterised in that** an output circuit comprises an output coupler to feed into a waveguide.

39. Device according to claim 38, **characterised in that** the output circuit is in the form of a single-column cavity.

40. Device according to claim 38, **characterised in that** all of the electron beam energy can be produced in the electron beam gun without post-deflection acceleration.